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Increasing the Durability and Reliability of Self-Compacting Concrete (SCC) Using Nano-Silica and Pozzolanic Materials in the Salt Environment

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Abstract: Through the expansion of concrete in Persian Gulf Region and short-term burnout of existing constructs considering critical and corrosive situation of this region, civil engineers and specialties are sought to improve concrete production in civil infrastructures in Persian Gulf using nano materials. Nano technology in recent years has drawn many attentions of researchers and scientists and its reason is using nanoparticles and their unique physical and chemical characteristics. On one hand, the cement is a material that sticks the parts of concrete and is used widely in construction projects. On the other hand considering its needs whether in terms of rigidity, strength, durability and high performance as well as corrosion of armatures in concrete due to the influence of chloride ions which is called as one of the durability and sustainability of reinforced concrete structures, concrete industry is one of Nanostructure material important users. This study has been written in order to improve the performance of Self-Compacting Concrete (SCC) using nano-silica in environmental situation of Persian Gulf (corrosive) three total plans including self-compacting concrete, self compacting concrete containing nano-silica and pozzolanic materials (micro-silica, fly ash and limestone powder) and their results were analyzed after placing in two situations of corrosive and aqua (salty Persian Gulf). For investigating the performance of mixtures above, the characteristics such as bending and compressive strength, the amount of expansion, contraction, water absorption, ultrasonic, electrochemical corrosion potential, penetration of chloride ion and the electrical resistance of examples located in ordinary water and salt destructive environmental situation of Persian Gulf and pseudo Persian Gulf with almost 5% of salt for 180 days have been investigated. Based on obtained results from the experiments, nano-silica improves the mechanical characteristics of self-compacting concrete such as bending compressive strength and durability against corrosive environments. In plans containing nano-silica and pozzolanic materials, it was observed that mentioned samples have better characteristics than the samples with mere nano-silica. Within this, the plans containing nano-silica and micro silicashowed better strength results besides concrete durability than other samples in salt destructive situation of Persian Gulf like Persian Gulf.

Key words: Self-compacting concrete, Persian gulf, nano-silica, durability, corrosive environment

INTRODUCTION

Concrete is one of the most consuming known materials in civil engineering that using it is increasing day by day. Within this, on one hand through developing science and the appearance of more complicated construction systems and on the other hand through expanding trend of civil construction especially in Southern coast of the Persian Gulf area at the macro level, newer construction materials with higher efficiency and durability in important and strategic area of Persian Gulf is tangibly required.

Concrete is known as one of the most consuming construction materials in the world. Through, expanding the use of concrete the characteristics such as durability, quality, compaction and its improving get special importance. Self-compacting concrete is very fluid and a homogeneous mixture that has solved many concrete problems such as detachment, bleeding, permeability and moreover gets compacted under the influence of its weight without needing any vibrator and this characteristic will significantly help the administration of construction members with high compression of reinforcing bar.

Replacing concrete with other materials is almost impossible in terms of its various functions. On the other hand attention to the concrete from attention to its components cannot be separated. The efficiency and characteristics of concrete depend on the amount and its microstructures dimensions to the great extent. The particles in nano aspects show different physical and chemical and unique characteristics and so using cement based on nano materials seems to cause producing concrete with high strength characteristics and very low penetrability.

Making a durable concrete has been mental and practical challenge of civil engineers since long time ago. Steel corrosion in concrete is one of the very important factors in reducing the durability of reinforced concrete constructs in area near Persian Gulf that the percentage of chloride ion inward concrete materials is very high. Expensive required resources for repairing the destructions derived by steel corrosion in concrete have multiplied the necessity of improving the situation of the constructs under building situation as well as guaranteeing the durability of newly repaired available constructs. Of very new pozzolanic materials that have been obtained by the help of recent progresses in nano technology is nano-silica that limited number of researches has been done relating to the features and characteristics of concretes containing this pozzolan. Considering the importance of identifying related problems to use of this added substance in concrete and familiarizing correct methods of consumption and its positive and negative features, main researches in this area seem necessary because through identifying this material it can be sued desirably due to improve the quality and durability of concrete.

Since, the results of many researches in the world show that using pozzolanic materials as a replacement for a part of portland cement in constructing concrete have multiplied the performance of such concrete against the attacks of sulfates and chlorides and other harmful substances so the current research is sought to investigate and search the characteristics and durability of self-compacting concretes containing pozzolanic of micro silica, fly ash with nano-silica and self-compacting concrete constraining limestone powder and nano-silica with control concrete SCC.

Self-compacting concrete: Self-compacting concrete is one of the latest achievements of concrete technology. The most important feature of this concrete is not requiringcompression and it will be formed under its weight. This important feature obviously enables many functions for this concrete that have been remained unknown for many engineers up to now. One of the most important problems that can be found in practical use of self-compacting concrete is that there is no accurate identification of that because of its newness and its standards are still developing.

Self-compacting concrete is considered in concrete group with high efficiency (powerful concrete). This concrete can pass easily among bars swarm and fill frame volume as well as being compacted under its weight without detachment and water ellipsis. High fluidity of self-compacting concrete paves the way for filling the mold without applying any vibration (Khayat, 1999; Khayat *et al*., 2004).

Self-compacting concrete can solve many problems on concretes simply so it is very important in concrete industry and construction. The subject of many researches especially in Japan and Europe is self compacting concrete and this shows the multiple importance of this subject (Mata, 2004).

It is noticeable that for achieving adequate compression and filling the space among reonforcing bar in self-compacting concrete, new concrete has to have two modes of high fluidity and good stickiness simultaneously because it is not only high fluidity, in fact when the concrete isn't sticky enough when concrete fluids near an obstacle, coarse aggregates may be stopped by obstacle and start cutting concrete mortar and stop the trend of concrete (ASTM, 2005). In 1975 and 1976 some of concretes that were qualified were studied. On that time, none of modern materials which were bases of super plasticizer and viscosity modifier agents was available. Despite this, simultaneous consumption of melamine or naphthalene with higher levels of aggregate proved that it can be effective on modifying viscosity and fluidity (Corinaldesi and Moriconi, 2004).

The function of self-compacting concrete because of mentioned characteristics is expanding in the modes of new concrete as well as after setting (Dehn *et al*., 2000).

MATERIALS AND METHODS

Environmental conditions and materials characteristics

Persian Gulf environment: Certainly the most important part of each experimental and empirical research is its practical phase because human, environmental and tool conditions and situations are very effective on obtained results. Therefore, practical phase should be accomplished with accurate planning and condition control. In this research, 4 concrete mixtures are made that two of them are self-compacting concrete containing nano-silica and three micro silica pozzolonic and fly ash as well as a self-compacting concrete containing nano-silica and limestone powder and one control self-compacting concrete. The consumed ultra-lubricant with PH equal to 7 and the aggregates are also the type of rounded corners and river with the biggest size of aggregate of 12.5 mm. mechanical features and samples reliability were also evaluated after fabrication and processing in both typical and salt water environments Persian Gulf.

Table 1: The characteristics of consumed nano-silica

Technical specifications	
Particles diameter	50 Nano-meters
Viscosity	CPS3
Color	Transparent milky
pH	10
Density (g/cm^3)	1.03

Table 2: Chemical analysis of Micro-silica

Micro-silica	
Chemical composition	Amount (%)
SiO_2	93.86
Al_2O_3	1.32
Fe_2O_3	0.87
CaO	0.49
MgO	0.97
Na_2O	0.31
K_2O	1.01
SiC	0.53
C	0.34
P_2O_3	0.16
SO_3	0.10
Cl	0.04

The features of materials

The characteristics of consumed nano-silica: This nano-silica has been as dissolved in water that the amount of solid material in it is 30%. Other characteristics of nano-silica have been mentioned in Table 1.

Cement: In this research, portland cement type 1-425 of Isfahan cement factory. The initial and final cement setting time has been respectively as 90 and 240. Its Blaine number is also equal to 3400 g/cm^2 (Yousef, 2009).

Micro-silica: Micro-silica used in this research is one of products by Vand Silica fume company with special level 200000 cm/g^2. The chemical characteristics of available components and oxides in micro silica are shown in Table 2. Mehrian *et al.* (2016) investigated the distribution of stress in different geometries including circular and rectangular domains (Nowruzpour *et al.*, 2013; Mehrian and Mehrian, 2015; Mehrian *et al.*, 2016; Vaziri *et al.*, 2015; Nowruzpour Mehrian and Naei, 2013; Nowruzpour Mehrian *et al.*, 2013, 2014).

Fly ash: The used fly ash in this research was provided from rah sahel company (ongoing project in Assaluyeh).

Limestone powder: Limestone powder was provided from qazvin company and all its particles have been passed through the leach no. 50.

Aggregates

Sand: Consumed sand has been provided out of minab sand mine belong to municipal mine which is the type of river materials. The used sand has uniform grained and maximum size of 12.5 mm seeds, special weight of 2.63 g/cm^3 and water absorption 2.14%. The quality of graining sand has been shown in Table 3.

Table 3: Graining sand and gravel

Sand and gravel grading according to standard (108 ASTM C33)				
Sand grading			Gravel grading	
Sieve size	Passing (%)	ASTM C33	Passing (%)	ASTM C33
12.5 mm	100.0	90-100	100	100
9.5 mm	56.6	40-70	100	100
4.75 mm	1.0	0-15	97.4	95-100
2.36 mm	0.2	0-5	82.4	80-100
1.18 mm	-	-	70.3	50-85
600 μm	-	-	52.2	25-60
300 μm	-	-	13.9	5-30
150 μm	-	-	2.2	0-10

Table 4: Technical characteristics of ultra-lubricants

Appearance	Brown liquid
Chemical base	Carboxylic salt polymer dispersions
Specific weight	kg/L 1.05
pH	About 7.01
Maintenance	Away from frost
Shelf life	Under ideal conditions up to 2 years
Packing	In 20 L gallons
Environmental features	Environment lover

Gravel: River gravel was used in two sizes of 0-3 and 3-6 mm. The maximum size of its grains 4.75 mm, special weight 2.52 g/cm^3, water absorption 3.26 and fineness modulus 2.82 as well as uniform graining were obtained. Ideal ratio of aggregates mixtures have been obtained by taking advantage of previous works in this field and with trial and error. So that 47.5% of mixture consists of sand and the rest is gravel. So that, gravel contains 85% size 0-3 mm and 15% of rest of it will have the sizes of 3-6 mm. The quality of gravel graining is shown in Table 3.

Water: Water quality is very important because its existing impuritiesmay affect cement setting and cause some disorders. In most of standards, appropriate water for mortar and concrete is the water which is drinkable. Consumed water in this project is drinkable water of Bandar Abbas.

Ultra-lubricant: Today, ultra-lubricants are widely used as additive in concrete in order to achieve high fluidity. In current research for all mixtures plan in order to achieve desired fluidity and better distribution of particles, ultra-lubricants based on carboxylic salt polymer dispersions equal to pH 7 was used. Table 4 shows technical characteristics of ultra-lubricants.

RESULTS AND DISCUSSION

Experimental researches and investigating the results: In order to investigate the features of fresh concrete

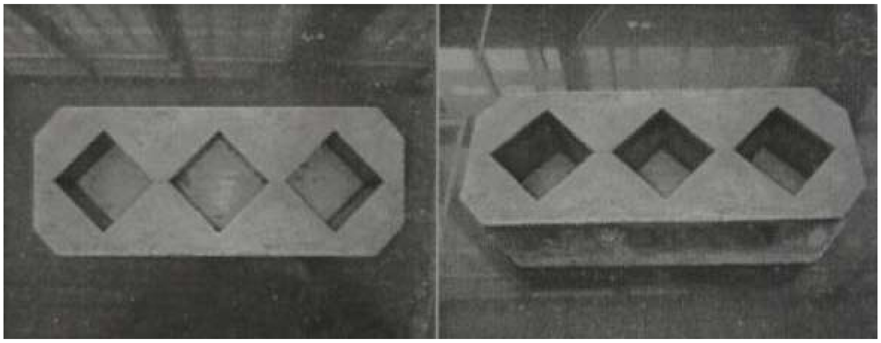

Fig. 1: The used molds for making the samples

including filling ability, passing ability and resistance to detachment, the experiment of slump flow, V (V-Funnel) and L (L Box) were done. The other research which was done on fresh concrete was the experiment of determining the amount of fresh concrete air. The experiments of compressive and bending strength was done on whole samples in the ages of 7-180 days in two aqua and corrosive environment of Persian Gulf. In order to confirm the effect of obtained results, various experiments and ultrasonic non-destructive approximate experiment was done on all samples. Also in order to investigate the rate of penetrability as well as sample's shrinkage behavior, the experiments of water absorption the age of 28 days the expansion and contraction of samples in different ages were done on samples and the results were compared with control samples. For determining corrosion index and the amount of concrete durability against corrosion the experiments of chloride ion, reinforcing bar corrosion potential and electrical resistance were done by placing samples in two aqua and corrosive environment (salty Persian Gulf) in 180 days and ages of 28, 60, 90, 120 and 180 days on samples.

The method of making the mortar specimens: Mixing method used in constructing the samples based on standard recommended method of ASTM (114 C305) was used.

Mortar compressive strength: Investigating this mechanical behavior of mortars was done based on standard (115 ASTMC109-99). The instruction of making mortar was explained before. Molding samples was done at most in 3 min and ultimately 30 sec after mortar construction. A layer of mortar with a thickness of about 25 mm (half the height of the mold) in forms of square cube shape with sides of 5 cm according to mentioned standard was poured (Fig. 1). The pressure of slamming was to the extent that the mortar inside mold was filled. The 4 phases of slamming were completed in each cube and then the other one was slammed. When initial slamming of the first layer was completed in all cubic parts the rest of mortars were used to fill out all parts and like the first layer, second layer was also slammed.

Ultimately the surface of samples was smoothed by trowel. The made samples were extracted out of mold after 24 h and maintained in water store with the temperature of 23±2 degree of centigrade. Before beginning loading the sample is dried and cleaned and loose granular materialswill be removed. The load was applied on smooth and flat surface of sample that was connected to mold body. The samples were inserted in the middle of machine's grips and no mediating material was as bed or pad among samples and the machine grips. The speed of loading based on mentioned standard should be based on 900-1800 Newton on second. In done researches, the speed of loading was 1350 newton on second. Loading was done by hydraulic jack system (controls) model 50-C5800. Final compressive strength was calculated based on the mean of three samples strengths. Based on mentioned standard some samples whose strengths is different from the average strength of similar samples that are made by that mortar and are experimented in same age >8.7% should be eliminated.

Optimization of the amount of nano-silica in mortar containing fly ash: This was done by making mortars with different percentage of nano-silica from 1-7% and the amount of 30% fly ash as cement replacement and the results of compressive strength experiment were done in the ages of 3, 7, 28, 60 and 90 days that has been shown in Fig. 2. As, it can be seen out of the picture, the mortar with 4% nano-silica rather than similar samples has had the most compressive strength and will be used as optimum percent.

Optimization of the amount of nano-silica in mortar containing limestone powder: This was done by making mortars with different percentage of nano-silica from 1-7%

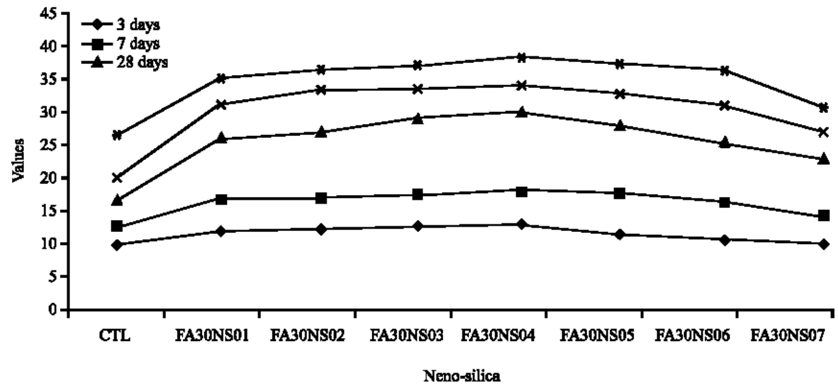

Fig. 2: Compressive strength of mortar with fly ash with different percentages of Nano-silica in different ages

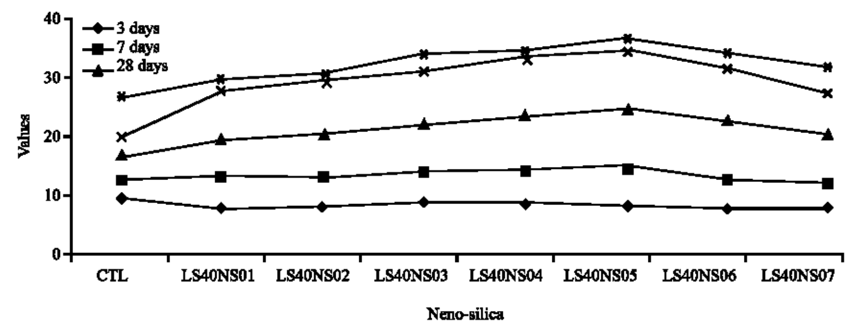

Fig. 3: Compressive strength of mortar with limestone powder with different percentage of nano-silica in different ages

Table 5: Weight characteristics of mixture plans

					Gravel						
SP (%)	W/(C+b)	Water	Sand	Nano (%)	3-6	0-3	LS	FA	SF	Cement	Plan name
Tempering schemes											
1/5	0.4	195	770	-	128	722	-	-	-	450	SCC (Ctrl)
1/5	4/0	195	770	5	128	722	-	-	-	450	SCC-Nano
1/5	4/0	195	770	3	128	722	-	-	45	405	SF10-Nano3
1/5	4/0	195	770	4	128	722	-	135	-	315	FA30-Nano4
1.2	4/0	195	770	5	128	722	180	-	-	450	LS40-Nano5

as cement replacement and the amount of 40% limestone powder and the results of compressive strength experiment were done in the ages of 3, 7, 28, 60 and 90 days that has been shown in Fig. 3. As it can be seen out of the picture the mortar with 5% nano-silica rather than similar samples has had the most compressive strength and will be replaced cement as optimum percentage of nano-silica in mixture plan of concrete SCC.

Making the samples of SCC concrete mixture plans: The method of used mixture in making concretes is based on recommended instruction (114ASTMC305) and with a little modification (because of pozzolonic material and use of ultra-lubricants) inspiring available studies is according to instruction. Based on the standard of making concrete, all samples of concrete should be maintained in mold for 24 h and then extracted out of mold and maintained in water tank with temperature of 23±2°C. The plan of mixing samples can be seen in Table 5.

Experiments

Slump flow: The experiment of slump flow is done in order to determine the movement freedom horizontally while there is no obstacle. The experiment is based some principles that ordinary slump experiment is based on those. The diameter of circle that concrete makes after spreading will be measuring criterion of concrete ability to fill. The results of this experiment don't refer the ability of passing without concrete closure through obstacles but it can be a criterion for measuring the strength against detachment.

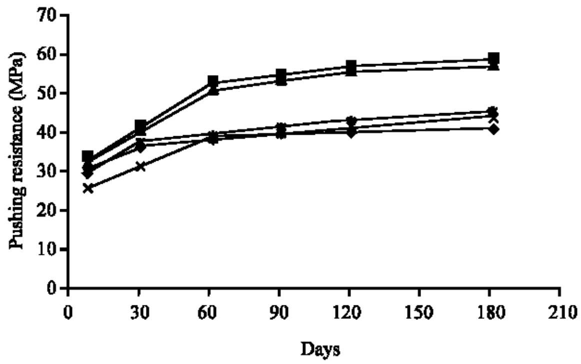

Fig. 4: The diagram of sample's compressive strength in different ages in aqua environment

Table 6: The results of fresh concrete experiments

Row	Slump flow (cm)	V funnel according to S	L Box H_2/H_1
SCC (control)	68.8	6/2	0.79
SCC+nano	46	6/9	0.82
SF10NS03	56	6.7	0.84
FA30NS04	70.5	6.8	0/98
LS40NS05	67/5	7/1	0/90

Fresh concrete experiments

V-funnel: The time of concrete exit out of standard V-funnel is measured and used as a criterion for estimating the capability of filling and dough viscosity of concrete. This experiment can be also used as a criterion for determining concrete detachment. In addition to thetime of concrete departure which is measured in this experiment the way of concrete exit out of funnel and the uniformity of exited concrete are also important. This system can also be a good indicator about the rate of concrete homogeneity intuitively.

L-box: This experiment represents the capability of spreading and passing self-compacting concrete. The existence or absence of concrete detachment can be also seen by eyes. This experiment is designed in order to investigate the capability of fresh concrete flow and obstruction of the presence of rebar. The results of fresh concrete experiments can be seen in Table 6. As it is clear from the results the samples are qualified for accepting the self-compacting concrete.

Compressive strength: The experiments of compressive strength according to standard 115ASTMC109 were done on cubic samples with sides of 10 cm. Making concrete according to given instruction was done in the section of making samples. Loading based on mentioned standard should be in limit 900-1800 newton on second that have been done on experiments this parameter was considered as 1350 newton on second. About the samples where width cross-section was different from nominal speed

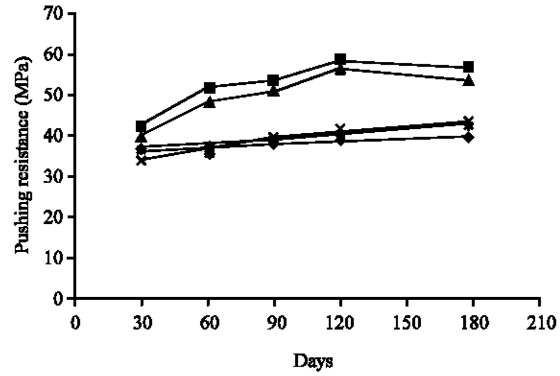

Fig. 5: The diagram of compressive strength of samples in different ages in salty environment of Persian Gulf

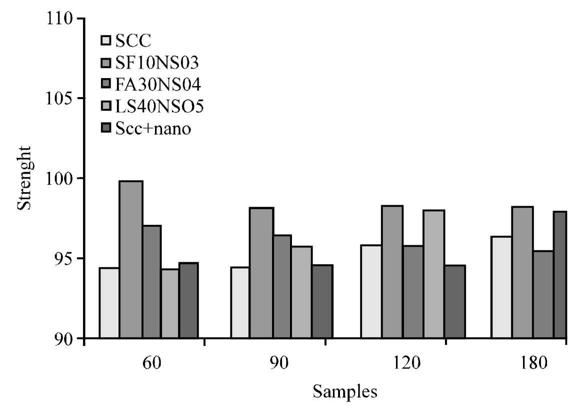

Fig. 6: The ratio of compressive strength in salty environment of Persian Gulf to the aqua one for samples

amount >1.5%, real cross-section surface was used. Final compressive strength was done based on the basis of three samples strengths mean (Fig. 4 and 5).

According to the diagram the dominant trend on diagrams in salty environment of Persian Gulf is similar to the dominant trend on aqua environment except totally the amount of strength in most of samples is less than available values in aqua environment (Fig. 6).

For comparing available values in two diagrams of aqua and salty of Persian Gulf the picture is drawn. Considering the diagram of the rate of strength reduction mediating presence in salty environment of Persian Gulf in SCC plan is 4%. The best pollozan for preventing corrosion in concrete SCC is silica fume that generally prevents strength reduction.

Bending strength: The experiment of bending strength was done on prismatic specimens of 28×7×7 cm and speed

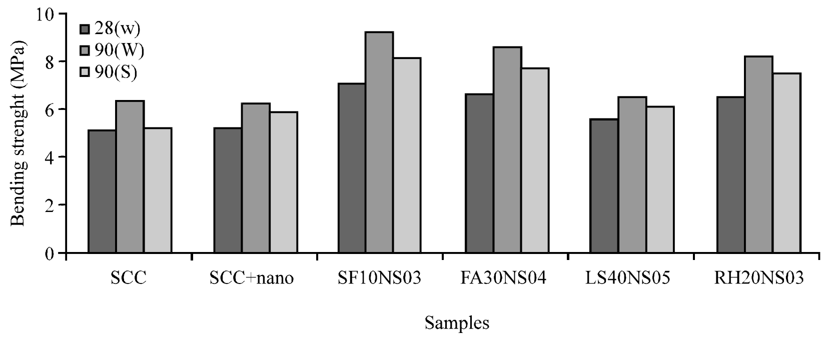

Fig. 7: The results of bending strength of samples

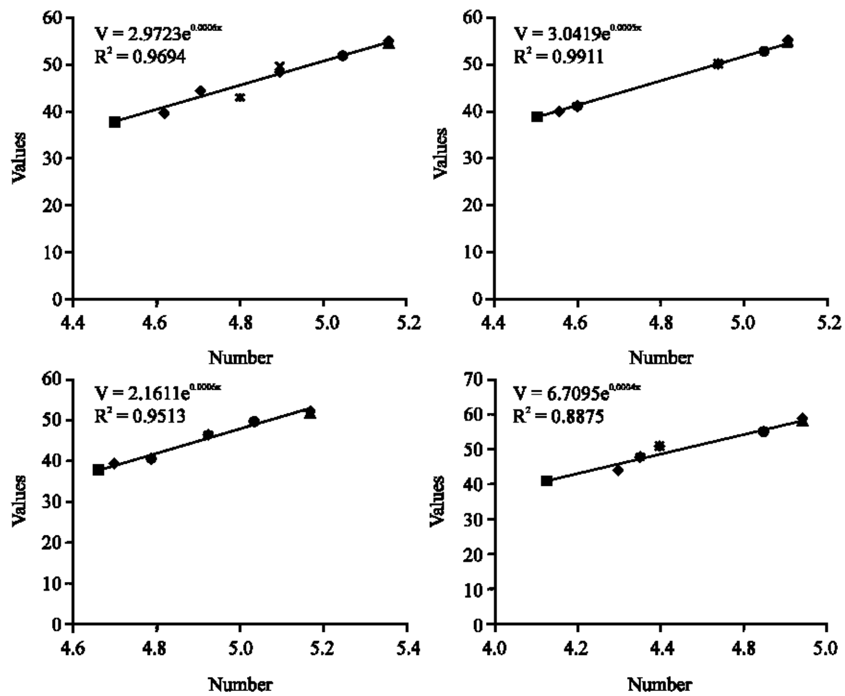

Fig. 8: The diagram of compressive strength against the speed of ultrasonic waves in both the 90 and 180 days ages

of (0.8-1.2 MPa/min). In accomplishing bending strength experiment it was tried to meet the requirements of standard 117ASTMC348 as much as possible. The results of sample's bending strength have been shown in Fig. 7 in two aqua and corrosive environment.

Ultrasonic experiment: In order to accomplish ultrasonic experiment in this research and provide calibration diagram the experiment was done on cubic samples with sides of 10 cm. Then by the help of curve fitness using the method of the least squares, equation below that shows the relationship between compressive strength and the speed of ultrasonic rays was analyzed and recommended (Eq. 1):

$$f_c = ae^{bv} \quad (1)$$

Where:

- F_c = Compressive strength of concrete based on kg on cm^2
- V = The speed of ultrasonic rays based on km on second and a and b are empirical coefficients

Empirical coefficients of a and b will be different for various types of concrete and concrete curing and age conditions. The speed of ultrasonic rays in samples located in salty environment of Persian Gulf is among 4400-5200 (m/sec). The concretes whose wave's passing speed is higher than 4500 are excellent ones, all concretes which have been located in aqua environment are high qualified. The existence of stone powder has caused that concrete body to be more solid and the number related to ultrasonic rays to be bigger (Fig. 8).

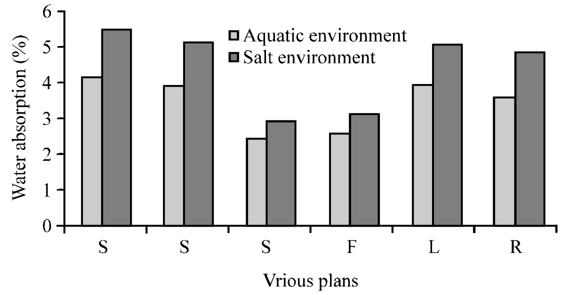

Fig. 9: The diagram of water absorption for two aqua and salty environment of Persian Gulf in 6 various plans

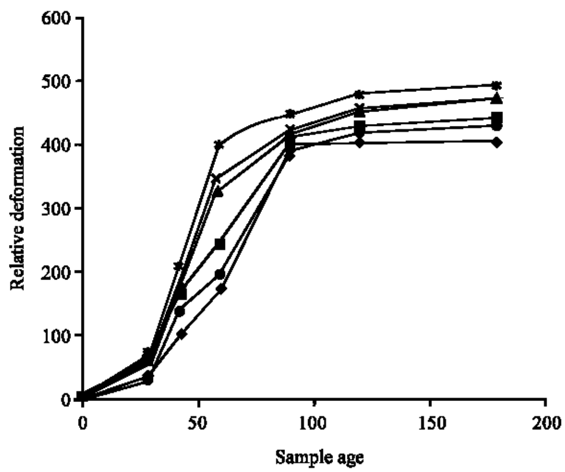

Fig. 10: The diagram of contraction of different mixtures

Water absorption experiment: Water absorption experiment was done on cubic samples with the sides of 10 cm in the age of 28 days. From each mixture, two cubic samples were made and ultimate water absorption was calculated based on taking the average of obtained water values from samples (Fig. 9).

Expansion and contraction experiment: Expansion and contraction experiment was done on prismatic samples of 30×4×4 cm. making samples and molding them was done in section of bending strength according to stated instruction. After getting samples out of the mold, the surface of samples that had been connected to the wall of mold was completely cleaned of oil and other existing impurities by a clean fabric. Contraction samples in laboratory environment and expansion samples were inserted in two salty and aqua environment of Persian Gulf. The first reading was done after 3 days of the installation of confetti and the rest of them were done in the ages of 7, 14, 28, 35, 60, 90, 120, 150 and 180 days by a special gauge with an accuracy of 2 μm (Fig. 10 and 11).

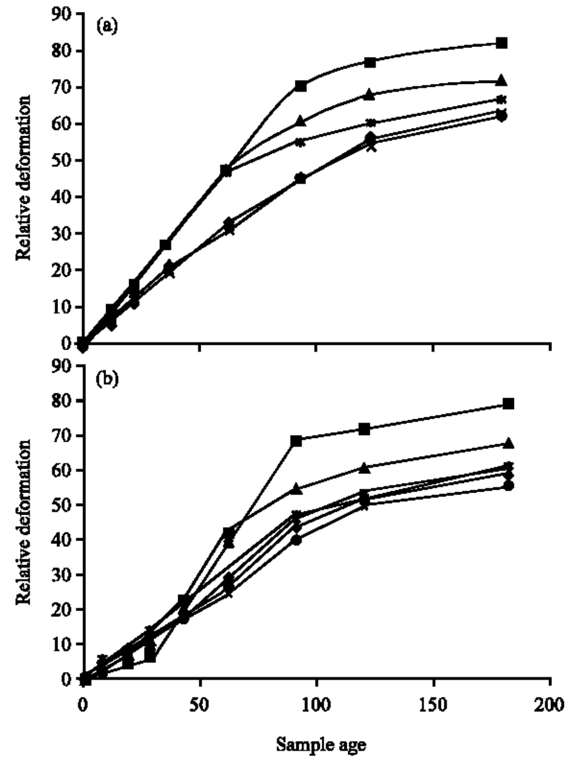

Fig. 11: The diagrams of the expansion of various mixtures in two; a) aqua and b) salty environments of Persian Gulf

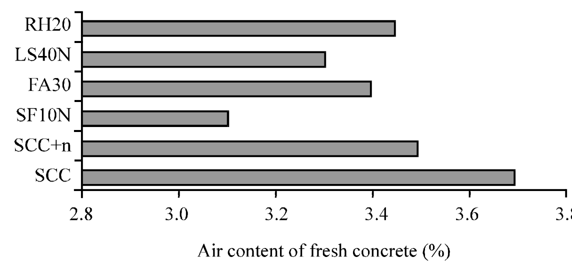

Fig. 12: The reuslts of experiment on the value of fresh concrete air

The value of fresh concrete air: Standard experiment of determining the value of fresh concrete mixture air was done through compressive method according to standard (122ASTM C231).

The results of experiment on the value of fresh concrete air of samples have been shown in Fig. 12. As it can be seen out of the results, self-compacting concrete has the highest value of air and all samples having nano-silica have less values of air. Among self-compacting concrete containing nano-silica the sample containing micro silica has allocated the least value of fresh concrete air to itself.

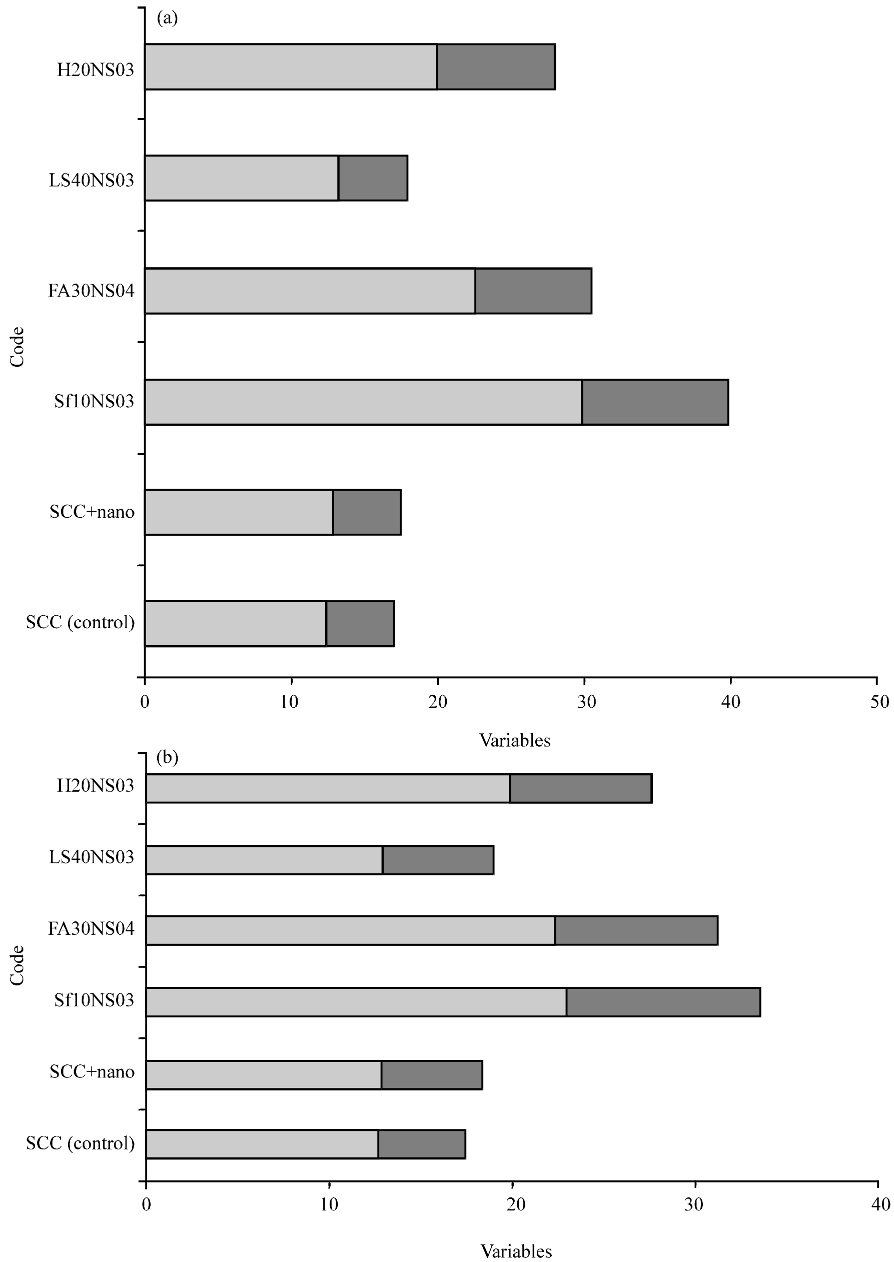

Fig. 13: a, b) The diagrams of electrical strength of 90 and 180 days samples in salty environment of Persian Gulf and aqua

Electrical strength: The results of electricall strength canbe seen in Fig. 13. In the age of 90 days in aqua environemnt, electrical strength of plans SCC, SCC+Nano, LS40NS03 is placed in a limit among 10000 to 20000 so corrosive potential of these samples is less. The plans SF10NS03 and FA30NS04 have electrical strength bigger than 20000 and their corrosive potential is less.

Bar graph represents that being in salty environment of Persian Gulf increases corrosive potential in all plans so that control concrete with electrical strength <500 will be in a zone with too much corrosive rate. The presence of nano-silica decreases corrosive potential somehow and causes the plan SCC+Nano to be placed in salty environment of Persian Gulf in the zone of very corrosive potential. The only sample which is average in corrosive potential among all plans is plan SF10NS03. The next graph also shows that through increasing the age of concrete, its corrosive potential will increase.

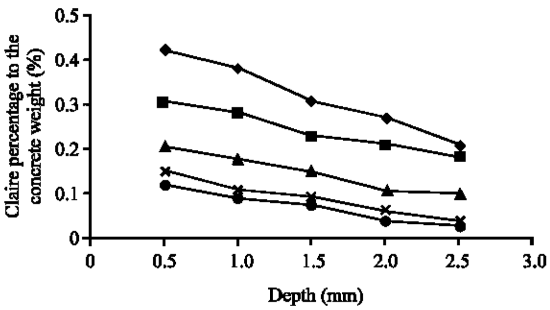

Fig. 14: The diagram of the amount of chloride in concrete in terms of the weight of concrete

Penetration of chloride ion in concrete: According to Fig. 14, the least value of chloride ion penetration in concrete belongs to plan containing silica fume because Blain number is high in silica fume and penetrability is less in concrete. The difference of the total permeability in two plans including stone powder and without that is significant at the presence of nano-silica. Fine-grained materials and solid concrete improve chloride penetration in it.

CONCLUSION

In order to investigate the effect of nano-silica on mechanical and physical characteristics of self compacting concrete containing micro-silica, fly ash and limestone powder and the durability of its samples in corrosive environments, first the experiments of fresh concrete including slump flow, V-funnel and L-box and the value of fresh concrete air was done and following that the experiments of compressive-bending strength, expansion and contraction, water absorption, ultrasonic, electrical strength, penetration of chloride ion and electrochemical potential of corrosive on samples were done. Considering the obtained results from done researches, it can be concluded as: adding nano-silica increases compressive strength of self-compacting concrete. Compressive strength of self-compacting concrete containing nano-silica will be more by adding more Pozzolonicmaterials and the value of increasing in self-compacting concrete containing micro silica will be more. For example compressive strength of 28 days of control self-compacting concrete of 36.19 mega-Pascal the concrete containing nano-silica and micro silica 42.06 mega-Pascal that shows the growth of 16%. This increase was obtained as 11% for fly ash.

The effect of salty environment of Persian Gulf on compressive strength of 180 days has been measured the strength of corrosive environment compared to ordinary environment. This value of self-compacting concrete contained 95% of nano-silica, concrete contained micro silica of 98.1% the concrete containedfly ash 95.4% and the concrete contained limestone powder of 106%.

Same as compressive pressure the results of samples bending strength experiment represent that adding nano-silica causes improving bending resistance of samples and so there will be more improvement in combination with Pozzolonic materials. The sample containing nano-silica and limestone powder had similar results as sample without mere nano-silica. The sample containing nano-silica and micro silica have the most bending strength rather than control sample and equal to 45% in the age of 90 days. Corrosive environment have caused reducing tensile strength of all samples.

Nano-silica with Pozzolonic materials in salty environment of Persian Gulf has caused reducing corrosive potential. The results of reducing corrosive potential for concrete containing mere nano-silica, nano-silica with SF, FA and LS, respectively as 2.6, 25.1 and 8.7% that show micro silica had the most effect and limestone powder the least effect.

The results of chloride ion experiment in salty environment of Persian Gulf show that nano-silica and Pozzolonic materials cause reducing penetration of chloride ion in samples. For example the depth of 2.5 the results of reducing penetration in concrete containing mere nano-silica , nano-silica with SF, FA, LS compared to control group were respectively as 14, 85, 81 and 52%. Micro silica and fly ash had the most effect on reducing the influence of chloride ion of samples.

Investigating the results of electrical strength represents that silica fume is the best pozzolan for preventing concrete corrosive in salty environment of Persian Gulf. Among used pozzolans in this research, fly ash had the most sensitivity against contraction.

RECOMMENDATIONS

- Investigating economic aspects of using nano-silica and Pozzolonic materials in self-compacting concrete
- Investigating the effect of acid and sulfate environments on durability and reliability of self-compacting concrete
- Investigating the use of nano-silica in strength against cycles of melting and ice in concretes containing micro silica, fly ash and other Pozzolonic materials
- Investigating the use of nano-silica with the combination of micro silica with fly ash in self-compacting concrete exposed to corrosive environment

- Creating prediction model of SCC useful life containing nano-silica te and Pozzolonic materials and comparing with usual concretes considering all effective factors in it
- Investigating the use of nano-silica on physical characteristics of SCC containing waste materials
- Investigating the use of Nano other materials and the possibility of their function in improving the characteristics of concrete
- Investigating the use of nano-silica in producing high-strength lightweight construct concrete

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